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A Choice Experiment Approach to assess the costs of degradation as specified by the EU Marine Strategy Framework Directive

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Abstract

This paper uses the choice experiment methodology to estimate the value of the non-market benefits associated with the achievement of good (marine) environmental status (GES) as specified in the EU Marine Strategy Framework Directive (MSFD). The MSFD requires that the "costs of degradation" (the benefits foregone if GES is not achieved) be considered within a broader 'Economic and Social Assessment' of the marine environment by EU member states. Assessing the costs of degradation as defined by the MSFD implies that changes in marine ecosystem services provided in each State should be analysed. The results show that there are high values attached with changes to the state of the marine environment by the Irish general public. The results of a random parameters logit model also demonstrate that preferences are heterogeneous, with changes in certain marine attributes generating both positive and negative utility.

Keywords: Marine Strategy Framework Directive, Marine Environment, Non-market Valuation, Choice Experiment, Ecosystem Services

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1. Introduction

The European Union (EU) adopted the Marine Strategy Framework Directive (MSFD) (EC, 2008) in February 2008. The Directive is aimed at achieving, or maintaining, good environmental status (GES) of Europe's marine and coastal waters, as measured by 11 descriptors, by the year 2020. Article 8.1 (c) of the Directive calls for 'an economic and social analysis of the use of those waters and of the cost of degradation of the marine environment'. This element of the directive will therefore require member states to estimate the value associated with changes in the environmental state of their marine waters that come about as a result of the implementation of the MSFD. As pointed out by Turner et al. (2010), the MSFD is 'informed' by the Ecosystem Management Approach, with GES interpreted in terms of ecosystem functioning and services provision. It is considered to be the first attempt to undertake an ecosystem management approach to protect and maintain the marine environment while ensuring that marine based activities are sustainable (Long, 2011). This ecosystem approach can also be considered a more holistic approach toward water body management compared to what has been perceived as a more prescriptive approach taken by previous water body related directives such as the EU Water Framework Directive (WFD), (EC 2000) Bathing Water Directive (CEC, 1976) and the Urban Waste Water Directive (CEC, 1991) (Borja et al. 2010).

Marine and coastal waters provide a variety of benefits to society generated through ecosystem goods and services (Ledoux and Turner, 2002). Some of these goods are valued by the market (such as fishing and aquaculture) but others, which are still valuable to society, are not captured by the market. These non-market goods and services are valued for the regulating functions they provide such as carbon sequestration, waste treatment and storm and flood protection in addition to cultural values such as recreation, aesthetic values and spiritual values (TEEB, 2010). These non-use values attached to the marine environment are considered to be a significant proportion of the total economic value of the benefits arising from the introduction of the MSFD (Bertram and Rehdanz, 2012) and substantial non-use values have been noted for changes to a broad range of environmental goods (Stevens et al, 1991, Bateman and Langford, 1997). TEEB (2010) also identifies non-use values that are not captured by the market and instead can only be estimated through the use of stated preference techniques such as contingent valuation (CV) and choice experiment (CE) methodologies.

Through the use of such stated preference techniques, estimates can be made of the additional non-market ecosystem service benefits that implementing the MSFD may provide[1]. Different economic valuation methodologies can be used to value non-market benefits accruing from the implementation of a marine environmental policy by assessing the public's willingness to pay for the outputs from such a policy as a whole or by modelling the preferences of society for the change in the component ecosystem services that result from the implementation of the policy. CE, for example, deal more explicitly with how society values relate to individual marine ecosystem related attributes, and combinations of attributes, while the CV method takes a more holistic approach by focusing on the value of (inter alia) moving from the status quo policy situation to an alternative where the marine environment is enhanced under a marine environmental policy. While both CV and CE can be used to estimate the value of improving the status of the marine environment, the CE approach has the advantage of being capable of measuring the marginal value of a change in the individual marine ecosystem services that are impacted by the policy (e.g. separate marginal values of improvement to benthic health, of enhanced recreation opportunities and of sustainable fish stocks) while a CV can usually only be used to value of the final specified change (e.g. value of achieving GES in marine waters) in the marine environment.

It should be noted that primary non-market valuation studies have previously been undertaken in connection with a number of EU policies concerned with coastal and marine ecosystem services. Georgiou et al. (2004) undertook a CV exercise examining the benefits of coastal water bodies meeting the EC Directive on Bathing Water (CEC, 1976) and the ecosystem service values resulting from changes to the same Directive were examined using a choice experiment by Hynes et al. (2013b). Elsewhere, Östberg et al. (2012) undertook a CV study examining coastal water

[1] Hynes et al. (2013a) and Brenner et al. (2010) used value transfer to estimate the value of various marine and coastal ecosystem goods and services within Galway Bay on the West coast of Ireland and the Catalan Coast respectively. These studies demonstrated that coastal and marine ecosystems generate large benefits but such secondary techniques are dependent upon a constant flow of primary estimates for these values, which in the case of marine ecosystem services are relatively scarce.

quality, boat noise and litter in coastal waters. These studies show that stated preference techniques using primary valuation methodologies can play a crucial role in helping policymakers to implement EU directives within the aquatic environment (i.e. revised Bathing Water Directive (EC 2006), the WFD and the MFSD). Further offshore, Armstrong et al. (2012) present a categorisation and synthesis of deep-sea ecosystem goods and services, and review the current state of human knowledge about these services, the possible methods of their valuation, and possible steps forward in its implementation.

Elsewhere, Eggert and Olsson (2009) used a CE with the attributes of coastal cod stock levels, bathing water quality levels, and biodiversity levels to estimate the values of changes in these aspects of a coastal marine ecosystem. Examining the offshore ocean, Jobstvogt et al. (2014) used CE to estimate the values attached to additional marine protected areas in the Scottish deep-sea which included attributes for deep-sea biodiversity and the potential of new medicinal products. McVittie and Moran (2010) also used a CE to estimate the non-use values associated with the introduction of marine conservation areas within the UK. The attributes in that study included biodiversity, environmental benefits (such as CO_2 sequestration, water treatment and recreation) and restrictions to fishing and marine extractive industries. The authors argued that non-use values compose a large segment of the values associated with changes to marine environment due to their spatial remoteness relative to other ecosystems.

A number of studies have also attempted to analyse the diversity within the marine and coastal ecosystem service valuation literature. Remoundou et al. (2009) for example undertook a review of valuation studies related to coastal and marine goods within the Black Sea and Mediterranean regions; finding thirteen relevant studies. Most of the studies were undertaken using the CV method (n=6) while two valuations used the CE method. They noted that further valuations are needed both for use and non-use marine and coastal goods and the potential for valuations to assist with policy and governance related to these resources. In another more recent paper, Ghermandi and Nunes (2013) examined the welfare impact of the recreational services provided by coastal ecosystems. The authors constructed a global database of primary valuation studies that focus on recreational benefits of coastal ecosystems and then build a meta-analytical framework using a Geographic Information System that allowed for the exploration of the spatial dimension of the valued ecosystems, including the role of spatial heterogeneity of the selected meta-regression variables.

Valuation studies have also been carried out that examine the non-market benefits associated with the implementation of the WFD. Bateman et al. (2009) for example used CV across five northern European countries to estimate the increased welfare associated with improvements in river water quality. Elsewhere, Brouwer et al. (2010) used a CE to value improvements in water quality in Spain while Hanley et al. (2006) and Stithou et al. (2012) used a CE to estimate values associated with improved river ecology in catchments in the UK and Ireland respectively.

In this paper, we add to the above literature by using the CE methodology to estimate the value of the non-market ecosystem service benefits associated with the achievement of good (marine) environmental status (GES) as specified in the EU Marine Strategy Framework Directive (MSFD). A novel feature of this research is that that the measures of meeting the MSFD, namely the 11 GES descriptors outlined within the Directive, were used to generate the attributes used in this CE. As such, this paper presents the results of the first study to attempt to value the 'Cost of Degradation' of the marine environment as set out in the MSFD. In what follows section 2 provides a description of the MSFD and briefly reviews the requirements for the valuation of marine ecosystem services within the directive. Section 3 then describes the CE methodology that is used to estimate the value of achieving GEV in Irish marine waters. Section 4 discusses the generation of the choice attributes and levels used in the application of the CE and other details related to the survey instrument. Section 5 presents the results and some discussion and conclusions are presented in Section 6.

2. The Marine Strategy Framework Directive

In trying to balance the demands on the marine environment with ensuring the sustainability of marine resources for future generations, the EU has put in place the Marine Strategy Framework Directive (MSFD) (2008/EC/56). The directive establishes a legally binding framework within which Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the 2020 at the latest. It is similar in scope and objectives to the Water Framework Directive (WFD) (2000/60/EC) and provides a framework model for achieving its aims rather than following a prescriptive approach. The MSFD allows for the interaction of plans with the WFD where there is coastal zone water bodies covered by both directives (but not transitional waters). The MSFD therefore complements the efforts of the WFD within the coastal zone.

The MSFD requires that EU member states (MSs) achieve GES in their waters by protecting, maintaining and preventing deterioration of the marine ecosystems and by preventing polluting inputs being introduced into the marine environment (Art. 1). This is to be achieved by developing and implementing strategies (Art. 5.1) that employ an ecosystem-based approach to the management of human activities in marine waters. GES is defined in the directive using 11 descriptors. A brief description of each descriptor is shown in Table 1 (in Appendix B). These descriptors have been further defined by Commission Decision (2010/477/EU). A marine water body is said to be at GES when all descriptors are at favourable levels. However, a recent report from the commission (EC, 2014) regarding the first phase of implementation of the MSFD found that the "quality of reporting varies widely from country to country, and within individual Member States, from one descriptor to another". Additionally, knowledge gaps were found across many countries in relation to data relevant to the 11 GES descriptors and a lack of data which could provide a baseline in which to measure change towards GES was also highlighted. Amongst its recommendations, the EU commission report indicated a need to review and improve the current Commission Decision Document 2010/477/EU by 2015 to produce a clearer, more coherent and comparable set of GES criteria that could also include the impact of climate change on GES.

The need to estimate the value of the benefits from achieving GES is driven by a number of elements required under the MSFD. The MSFD refers to the “costs of degradation”, which has been taken to mean the benefits foregone if the MSFD is not implemented. Bertram and Rehdanz (2012) identified the four main requirements for the valuation of ecosystem service benefits within the MSFD. These are:

- Initial assessment of a Member States' marine waters, including economic and social analysis (ESA) of the use of those waters, and of the cost of degradation of the marine environment (Art.8.1(c) MSFD).
- Establishment of environmental targets and associated descriptors describing GES, including due consideration of social and economic concerns (Art.10.1 in connection with Annex IV, No. 9 MSFD).
- Identification and analysis of measures needed to be taken to achieve or maintain GES, ensuring cost-effectiveness of measures and assessing the social and economic impacts including cost-benefit analysis (Art.13.3 MSFD).
- Justification of exceptions to implement measures to reach GES based on disproportionate costs of measures taking account of the risks to the marine environment (Art.14.4 MSFD).

Also, it has been shown throughout the literature that non-use values can form a significant portion of the total economic value of the marine environment to society (McVittie and Moran, 2010, Bertram and Rehdanz, 2012). It should also be noted that while any costs associated with implementing elements of the MFSD may be relatively easy to determine (e.g. through foregone revenues or costs of monitoring rules), the estimation of benefits may be more difficult and costly to determine. As is evident from the brief review of the literature in section 1, the CE approach is a suitable methodology to estimate the non-use value of improvements to the marine environment as required under the MFSD and has been used previously both to estimate the values associated with changes to the marine environment and other EU directives. The presentation of the 11 descriptors in the Directive is laid out in a manner that also them suitable attributes to be considered for inclusion in the CE.

3. The Choice Experiment (CE) Method

Stated preference techniques are the only methodologies that can be used for estimating both the use and the non-use value of a change in the environment. As mentioned previously, it is expected that a significant portion of the benefits arising from the implementation of the MSFD will be associated with the non-use values of protecting the marine environment due to the large spatial area covered by the directive and the low number of users of marine ecosystems relative to many users of terrestrial ecosystems. The use of stated preference techniques such as CE or the CV method will therefore be required in order to estimate the welfare impacts resulting from the environmental improvements that are expected under the directive.

The CV method derives values of a non-market good or service by presenting people with a hypothetical situation in the form of a questionnaire. The values are 'contingent' on the respondent's willingness to pay or willingness to accept a change to the good or service being valued (Ryan and Watson, 2008). This methodology is widely used to value stated preferences for environmental goods (Bjornstad & Kahn, 1996). An alternative to the CV method, and the tool used in this paper, is the CE approach where instead of a change in one attribute, the good is broken down into a number of attributes, each with their own levels (Haab and McConnell, 2002)[2]. Respondents are then asked to choose between different sets of these attribute levels. By including a price attribute within the choice sets, the value of a change between different levels of an attribute can be estimated[3].

Both CV and CE have an advantage over revealed preference methods of valuation (such as the travel cost and hedonic price methods) in that they can handle both use and non-use values and also the different types of non-use values. Non-use values can be decomposed into a number of types; an existence value where the person holds a value for the maintenance of the marine waters in a healthy state regardless of their use, a bequest value where the value arises from being able to pass on the marine waters in a healthy state to future generations and an altruistic value where the value is generated from knowing that other people (including one's family and friends) may benefit from the use of a healthy marine ecosystem. However, respondents to stated preference surveys may also be motivated by other factors including potential or current use of the marine environment.

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[2] The CE method offers more flexibility compared to the CV method as it allows the environmental change to be broken down into a number of attributes and the different levels that they could take. Including a monetary amount at various price levels can allow a willingness to pay (WTP) for marginal changes to each of the attributes to be measured. Scenarios related to changes in the environment can be constructed and WTP for each of these can then be compared. A disadvantage compared to the CV method is that the CE method requires more of the respondents, both in terms of time and cognitive ability in answering the survey and is more complex and time consuming to analyse.

[3] For a further in-depth examination of the CE methodology and its application to policy the interested reader is directed towards Birol & Koundouri (2008).

Stated preference techniques can handle all of these categories of use and non-use and, as previously discussed, have been employed for a variety of valuation exercises within the environmental economics field (Atkinson et al., 2012, Hanley and Barbier, 2009). Their use for decision making within policy has also been generally accepted (Arrow and Solow, 1993) and the results from stated preference methodologies are often used in conjunction with other data to guide the environmental decision making process.

The use of the CE methodology originated within the spheres of marketing and transport research (Louviere and Woodworth, 1983; Louviere, 1988) but has spread to other policy areas including environmental economics (Hanley et al., 1998). The CE methodology is based upon the concept known as "the characteristics theory of value" (Lancaster, 1966) where a good may be thought of as being composed of a number of characteristics or attributes, which the respondent values independently, rather than valuing the good as a whole. The theoretical framework behind the analysis of CE data is random utility maximization (McFadden, 1974). The random utility maximization (RUM) expression of the utility *U* associated with choice alternatives *(0,1...J)* for individual *i* can be written as:

$$
\begin{aligned}
&U_{i1} = \beta_0 X_{i0} + \varepsilon_{i0} \\
&U_{i1} = \beta_1 X_{i1} + \varepsilon_{i1} \\
&\ldots\ldots\ldots\ldots \\
&U_{iJ} = \beta_J X_{iJ} + \varepsilon_{iJ}
\end{aligned} \tag{1}
$$

The observed outcome is then denoted as

$$yi = \text{choice } j \text{ if } Ui(\text{ alternative } j\ ) > Ui(\text{ alternative } q\ )\ \forall\ q \neq j. \tag{2}$$

where X_J is a vector of explanatory choice attributes of the alternatives weighted by the unknown parameter vector β and ε is the random error term, which represents the unobserved variations in taste that influence choice.

The RUM model can be specified in different ways depending on the distribution of the error term. If the error terms are independently and identically drawn from an extreme value distribution, the RUM model is specified as multinomial (conditional) logit (McFadden, 1974). This can be expressed as:

$$\text{Prob(choice } j) = \text{Prob}(\text{U}j > \text{U}q),\ \forall\ q \neq j \tag{3}$$

$$= \frac{\exp(\beta_j x_{ij})}{\sum_{q=0}^{J} \exp(\beta_q x_{iq})}\ \ , j = 0, \ldots, J \tag{4}$$

A conditional logit (CL), as described above, was used initially on the dataset of valid choices. This is the basic model in the stable of CE models and it allows an initial exploration into the preferences of the respondents. However, the CL is based on a number of restrictive assumptions including independently and identically distributed error terms (IID) and independence of irrelevant alternatives (IIA). McFadden and Train (2000) showed that mixed logit models provide a more flexible and computationally practical econometric method for estimating a discrete choice model derived from the random utility maximization framework that can overcome these limitations. Additionally with the use of a mixed logit model it is possible to account for dependence across repeated choices made by the same respondent by specifying a panel version of the model. The random parameters logit (RPL) is one type of mixed model and was used in this case as it allows these assumptions to be relaxed. The use of RPL also allows for random taste variation, unrestricted substitution patterns and correlation in observed factors (Train, 2003).

In the random parameters logit (RPL) (Train, 1998), the unconditional choice probability is the integral of logit formulas over all possible variables such that:

$$P_{ni} = \int \left[\frac{e^{\beta_n' x_{nit}}}{\sum_j e^{\beta_n' x_{njt}}} \right] f(\beta) d(\beta) \tag{5}$$

However unlike the CL model, the integral in equation (5) does not have a closed form for integration. Therefore simulation is needed to obtain a solution and calculate the probabilities. Train has developed a method that is suitable for simulating (5). His simulator is smooth, strictly positive and unbiased (Brownstone and Train 1998), and can be easily modified to allow for non-negative/positive random parameters. Simulating (5) is carried out simply by drawing a β_{nr}, calculating the bracketed part of the equation and repeating the procedure a number of times. Although Train's simulator is unbiased for just one draw of β_{nr}, its accuracy is increased with the number of draws. Using R draws of β_{nr} from $f(\beta)$, the simulated probability of (5) is:

$$P_{ni} = \frac{1}{R}\sum_{r=1}^{R}\left[\frac{e^{\beta'_{nr}x_{nit}}}{\sum_{j} e^{\beta'_{nr}x_{njt}}}\right] \tag{6}$$

The subscript *nr* on β indicates that the probability is calculated for each respondent using R different sets of β vectors. For the RPL the modeller must decide which β coefficients are to be estimated as random and how they are to be distributed $f(\beta)$. Allowing all β coefficients to be random would result in a virtually identified specification (Ruud, 1996) so in this paper we keep the price fixed as is common practice in the literature (Martin-Ortega et al., 2012; Birol et al.,2006). When employing the RPL model the modeller must also decide on the parameterization of the covariance matrix. In this paper we also allow preference parameters to be correlated. The covariance matrix and correlations across the random parameters are shown in Appendix A. To estimate the model a simulated maximum likelihood estimator with Halton draws was used. In the final estimation of the model 300 Halton draws were employed.

In order to estimate a marginal value for each of the marine environment attributes in the choice experiment, a price attribute was included. This allows the monetary welfare impact to be calculated of moving from the current marine environment today (i.e. the status quo) to an alternative marine environment with attribute levels set to be representative of what could result if the MSFD was or was not implemented (i.e. the cost of marine environment degradation). The marginal willingness to pay for the different marine environmental attributes (often referred to in the literature as the implicit prices) and the welfare impact from a move from x^0 to x^1 and conditional on individual taste β_n being logit can then be derived using the standard compensating variation (SCV) log-sum formula (Hanemann, 1984):

$$SCV = -1/\beta_m \left[\ln\left[\sum \exp(\beta' x_n^1)\right] - \ln\left[\sum \exp(\beta' x_n^0)\right]\right]. \quad (7)$$

With the use of a RPL model, the welfare measure needs integration over the taste distribution in the population so that:

$$SCV = \int \left\{-1/\beta_m \left[\ln\left[\sum \exp(\beta' x_n^1)\right] - \ln\left[\sum \exp(\beta' x_n^0)\right]\right]\right\} f(\beta) d(\beta). \quad (8)$$

This integral is also approximated by simulation from draws of the estimated distributions for the random parameters in our chosen model (Hynes et al., 2008). Using the above formula (8), the welfare impact of a change in the marine environmental attributes from the status quo scenario to various possible future scenarios may be calculated.

4. Marine Strategy Framework Directive (MSFD) Choice Experiment

For estimating the non-use ecosystem service benefits associated with the achievement of GES as specified in the MSFD, the CE was thought to be an appropriate method as the overall goal (achieving GES by 2020) was already defined by a number of descriptors (See Table 1), which could be used as attributes in the choice cards presented to the public. This differs from the more common approach where the attributes of a choice card used within a CE are generated after reviewing the literature and/or followed by consultations with experts or stakeholders through the use of focus groups. In the CE presented in this paper the attributes are based directly on the policy text. Having said that, it was decided that 12 attributes (11 descriptors and a price attribute) would be too difficult cognitively for respondents to be able to effectively trade off the attributes against each other. It was therefore decided to combine related descriptors into single attributes. Willis et al. (2005) stated that in a CE, respondents cannot trade off too many attributes without adopting some heuristic rule. They noted that Miller (1956) suggested that in accurately being able to rank attributes, seven (plus or minus two) was the limit of most people's cogitative abilities. Willis et al. (2005) suggested that four or five be the maximum number of attributes used.

Based on consultation with experts in the field of marine science and following testing with focus groups, certain MSFD descriptors were combined to create joint attributes (shown in Table 1). This was done in order to lower the cognitive burden on respondents. Six attributes were eventually decided upon, including a price attribute. Table 2 (in Appendix B) shows which MSFD descriptors were combined to generate the attributes used in the choice card. Table 3 (in Appendix B) shows the attributes and the different levels used for each attribute.

Prior to being presented with the attributes and the choice cards in the experiment, respondents were given some background information on the MSFD and the state of Ireland's marine environment. Following this the following preamble was used;
"*The health of the marine environment is measured using a number of attributes. We have combined these attributes into different scenarios. We ask you to look at a number of choice cards, where you will have 3 choices. For each choice card, please choose one option. Within each choice card there will always be a choice (Choice C) reflecting the status quo in which you pay nothing. If you choose an alternative, there will be an amount that you as an individual will have to pay annually for the next 10 years to help protect the Irish marine environment under this alternative. Payment is expected to be made through a ring fenced tax dedicated to protecting the marine environment either through your income tax or VAT. Please consider how much money is available in your budget considering all your other expenses before making your decision.*
Before you make your choices please let us describe the different attributes that measure the health of the marine environment and the levels associated with them."

At this point the description of each attribute in the choice experiment was presented (as shown in box 1) and a sample choice card (see figure 1 in Appendix B) was worked through with each respondent. The levels of the attributes were described using qualitative measures rather than quantitative measures due to fact that for Irish marine waters there is currently insufficient quantitative evidence related to the main descriptors of the MSFD to develop any meaningful measures. The levels used for each of the attributes are shown in Table 3.

Box 1. Description of Attributes

a) Marine Biodiversity and Healthy Ecosystem

High levels of biodiversity are often a sign of a healthy well-functioning ecosystem. An area has high biodiversity if there are high numbers of different species (especially high level predators), high numbers of those species and the areas in which they live are protected from damage. Biodiversity and healthy ecosystems in Irish waters are known to be under threat from a variety of human activities (i.e. fishing, pollution, marine construction, etc). Currently, most of the seas and oceans around Ireland are rated as at good status with some areas of moderate and poor status; without protection, it is expected that biodiversity will decrease (less species) and there will be a reduction in the area and number of healthy ecosystems.

b) Sustainable and healthy fisheries

The sea provides a variety of fish species which are both nutritious and tasty. In Irish seas while some fisheries are currently have stable populations (e.g. it is sustainable to harvest them) and are safe to eat, other fisheries have been overfished and no longer produce the same yield as in previous years (e.g. it is unsustainable to harvest them). Providing sustainable fisheries may mean closing some fisheries in the short term to allow fish stock to replenish so that they are available both for us in the longer term and for future generations. Management may also be required to ensure fish are healthy and safe to eat.

c) Pollution levels in sea

A variety of polluting substances and litter are known to be entering the seas around Ireland. These pollutants can cause damage to marine environment (e.g. oil slicks), can affect humans by being absorbed through eating fish and can cause harmful algae blooms (e.g. red tides) which can close bathing areas and cause shellfish poisoning. Marine litter can look unsightly and cause damage to marine life. Preventive measures will be needed to reduce the levels of pollution and litter in Irish seas.

d) Non-native species

Marine non-native species are animals and plants that humans transport to Ireland either on purpose or accidently (attached to ships or in ballast water of ships).There are small numbers of marine non-native species in Irish marine waters currently. Non-native species are known to cause damage to oyster beds and disrupt ecosystems. Without preventative measures, these species could spread and new non-native species could travel to Irish waters.

e) Physical impacts on the sea

Physical altering the seabed and changing flows can cause damage to habitats on which various marine species depend and also may cause pollution by stirring up pollutants which were buried in the seabed. Different human activities in the sea and on the coast can change the sea bed and the flows of tides and currents. Underwater noise caused by sonar, ships propellers and construction within the marine environments can also cause disturbance to fish populations and induce stress in marine mammals that use sonar like whales and dolphins. It is expected that some of these activities will increase in the future which is expected to cause more changes to the sea bed and flows. Management of these activities will be needed to prevent significant damage to the marine environment.

For the *Non-native species* attribute, there was some evidence (Lützen et al. 2011) that some marine non–indigenous species can alter an ecosystem by 20% so this was also presented as the extreme level along with a general description. Additionally, the focus groups thought that the word ‘non-native’ was easier to understand than ‘non-indigenous’ for the *Non-native species* attribute. The *Sustainable and healthy fisheries* attribute combined the two fisheries related descriptors in the Directive. The attribute had three possible levels (sustainable & healthy to eat, sustainable and unhealthy to eat, or unsustainable and unhealthy to eat). The unhealthy to eat level was assumed to be as a result of the fish being contaminated. Contaminates are often as a result of high pollution and this attribute was expected to be correlated with the pollution attribute. This was one of the reasons that the random parameters mixed logit model was preferred as it can take correlation between attributes into account. [4]

The price attribute used was based on a ten year ring fenced tax that the respondent would have to pay, a common instrument in the environmental valuation literature. While the aim of this survey is to estimate the "cost of degradation" the question is framed as "paying for improving the environment" through the medium of a tax increase. This approach was taken as a tax is the most realistic payment method that can be used for a public good. Also the “costs of degradation” is interpreted here as the benefits foregone if GES is not achieved and the willingness to pay via taxation for marine ecosystem service benefits should reflect the value in the loss of such services under any scenarios considered. The fact that environmental ring fenced taxes are already used in Republic of Ireland (Convery et al., 2007) also meant the respondents would be familiar with this payment method. The tax is meant to allow the respondent make a payment that will assist in changing the current trend of degradation of the marine environment, which the raison d'être for the implementation of the MSFD in the first place. Dunlap et al. (2002) have described how

[4] This expectation was borne out in our results (See appendix A) as the correlation between the unsustainable and unhealthy to eat level of the Sustainable Fisheries attribute is correlated with both the pollution attributes levels (Increasing pollution; 0.37 , Pollution at current levels; 0.66)

environmental problems have generally tended to become more geographically dispersed, less directly observable, and more ambiguous in origin which may lead to the belief that people cannot understand a trend towards a deteriorating environment. However, other studies (Gifford et al., 2009, Dunlap et al., 1993) have found that there is temporal pessimism for the environment i.e. that things are getting worst over time with Gifford et al. (2009) noting " awareness of environmental deterioration seems to be so strong that it overrides the default bias towards optimism". With this in mind, we consider that the any framing issues related to the use of tax as a payment vehicle within the survey should be slight.

Finally, in light of an increasing amount of taxes and charges being imposed on the Irish general public at the time of conducting this CE, the focus groups felt that the highest payment level presented should not be more than €100 as this was the standard charge for an unpopular household charge at that time. Therefore the maximum amount chosen for inclusion as a payment level was €70. The values used were reassessed following the pilot study but given no issues arose; the values were kept the same for the main survey.

The CE employed a Bayesian design based on the multinomial logit parameter estimates obtained from the pilot study data. This created 24 initial profiles that were used to generate the choice cards. The initial 24 marine policy profiles were blocked into 2 versions of 12 choice cards, each containing three marine environment alternatives: option A, option B and a status quo. The status quo alternative represented a continuation of current levels in all the marine attributes and therefore a zero additional tax (price) was associated with the status quo alternative. Generic alternatives A and B contained variations in the attribute levels, but with a positive tax price, representing modification to current policy support. The software Ngene was used to generate the Bayesian efficient design based upon minimising the Db-error criterion (Louviere et al., 2000)[5].

A market research company was employed to collect the data during 2012 (both pilot and main survey). The survey company collected the data face-to-face with

[5] The interested reader is directed towards Scarpa and Rose (2008) for an outline and discussion of the efficient experimental design literature.

respondents in their home. The surveyors were instructed to go through the survey carefully with respondents and to ensure that the proper explanations of the attributes were given. In carrying out the CE, a survey of 812 individuals living in Ireland was conducted between September 2012 and November 2012. The survey of the Irish general public was undertaken throughout the Republic of Ireland and was done on a face to face basis. A quota controlled sampling procedure was followed to ensure that the survey was nationally representative for the population aged 18 years and above. The quotas used were based on known population distribution figures for age, sex, occupation and region of residence taken from the Irish National Census of Population, 2011. A comparison of these and other characteristics between the survey and the Irish National Census of Population, 2011 survey of Ireland is shown in Table 4 (in appendix B). Based on these characteristics the survey respondents are considered to be representative of the general public in the Republic of Ireland.

Results from the pilot were used to refine the questions asked in the main survey. The pilot survey was undertaken during the month of August 2012 and consisted of 56 interviews. The main survey was undertaken during September and November 2012. The survey consisted of a number of attitudinal questions and questions on use of the marine and coastal environment (relating to recreational activities and marine produce consumption) before the CE section of the survey was undertaken[6].

5. Results

The choice data was first examined for trends in choices across individuals. Examining the choices of those who opted for change indicated that there was only one respondent who chose all option A and one who chose all option B on all 12 choice occasions. This indicates that the majority of those who opted for change avoided adopting simplistic choice heuristics. Fifty percent of the respondents always chose option C (the “status quo”), which had zero payment attached. This represents a high proportion of the sample. A follow up question to those respondents that always chose option C was included in the survey. This allowed those respondents to outline their reasons for always choosing option C (Table 5 in appendix B).

[6] Only the results from the main survey are shown here due to differences in the survey and in the choice cards between the pilot and main survey.

It can be seen from Table 5 that the most common reason for always choosing the status quo option was that the respondent could not afford to pay. The high proportion stating they cannot afford to pay may reflect the impact of the downturn in the Irish economy since 2007. The other most frequent reasons for picking option C was that others should pay (the Government/ EU or those who pollute) and concerns that the measures described would not be introduced. However, these reasons do not reflect the fact that these respondents may still hold a non-zero value for changes to the marine environment. Therefore, the only responses that were considered genuine zero-value responses and that were included within the sample for analysis were those that stated "The improvements were not important to me" or "The 'No Change' option is satisfactory" or "I don't use the sea or marine environment". The sample size employed for the choice analysis was therefore 412 respondents[7].

The results from the RPL are shown in Table 6 (in appendix B). Both the mean attribute level coefficients and their standard deviations (modelled as normally distributed) are presented. The mean coefficients of all attribute levels have negative signs and are significant at the 95% level except for a *decrease in biodiversity*, which is insignificant[8]. This indicates that on average, respondent's utility would increase by moving towards GES in Irish marine waters. However, all the standard deviations are significant and some of them are quite large relative to the means indicating that there is sizable heterogeneity in people's preferences for changes to the marine environment. Additionally, the individual level parameters were analysed for differences between groups related to age, gender, education and work status was used as a proxy for income as not every respondent reported income. It was found that for a change from *biodiversity increases* to *biodiversity maintained at current levels* the loss of utility measured as implicit prices was significantly less for those with a third level

[7] The exclusion of respondents whose reason for consistently picking the status quo due to income constraints in a choice experiment is considered valid. This is due to the public nature of the good being valued and the method which was used to value the good. Using WTP for valuing public goods introduces a budget constraint. While having a budget constraint is not a protest response (Meyerhoff & Liebe, 2008), to include these as valid zeros is still not satisfactory. A public good (the marine environment) is non-rivalrous; the change in the level of that good may be enjoyed or imposed upon everyone regardless of payment. Thus if people cannot afford to pay, they lack the means to signal how the measure (i.e. the change in the environment) will affect their social welfare. By including those respondents we would underestimate the value of the change as they would have a null value substituted for their real value. The exclusion of 'cannot afford to pay' zero bidders is a common practice in the literature (Doherty et al., 2014).

[8] For each attribute the levels associated with GES are taken as the base case and coefficients are therefore only presented for the alternative levels in each case.

background (-€14.13) compared to (-€17.33) for other levels of education. However the opposite is true for a change in the *physical impacts to the sea* attribute from *limited damage to moderate damage* with those with a third level education having a larger loss (-€24.23) compared to the utility lost for other levels (-€19.80). There were no significant differences found in parameter estimates across age, gender or work status.

The largest change in utility levels was found to be associated with the change from the status quo (as demonstrated by the magnitude of the Alternative Specific Constant (ASC) dummy) indicating that respondents in general are in favour a change to a different marine environmental scenario. The next largest changes in utility is associated with an increase in pollution (-2.008) followed by unsafe and unsustainable fisheries (-1.972). Changing from a decrease in pollution to an increase in pollution will result in a marginal cost per person per year of €74.37 and changing from sustainable and healthy fisheries to unsustainable and unhealthy fisheries would result in a marginal cost of €73.04. The large changes in utility levels make sense as both of these attributes affect people either directly if they visit the coast (beach litter, wastewater, pollution in the water) or if they eat fish or shellfish. The physical impacts to the sea attribute with levels ranging from limited damage to moderate and wide scale damage were also associated with significant changes to utility.

The attributes related to biodiversity and invasive species were not as clear to interpret as the previously discussed attributes. While *increased biodiversity* is preferred to the current biodiversity levels (-0.451) there is no difference seen in utility levels from an increase to a decrease. However it can be seen that there is large and significant standard deviation for this latter level. Figure 2 (in appendix B) shows the distributions of the two biodiversity level coefficients in the RPL model. It can be seen that less than 33% of respondents preferred to maintain current levels compared to an increase. However the larger standard deviation associated with a decrease in biodiversity shows that there are stronger preferences in both directions with only a slight majority (52%) favouring an increase over a decrease in biodiversity. This unexpected result may be because of difficulty in understanding the biodiversity concept; people may have strong views (indicated by the large standard deviation) supporting the human activities that affect marine biodiversity (fishing, marine construction). These were activities mentioned in the description of the attributes to respondents as shown in Box 1.

Although both the invasive species level coefficients are of the expected sign, the size of the coefficients are slightly inverted from what was expected with a lower loss of utility associated with a change from no invasive species to new invasive species (-0.683). This compares to the loss of utility associated with the change from no invasive species to existing invasive species (-0.746). Similar to the biodiversity levels, the seemly inverted level was associated with a large standard deviation. Trying to interpret this, it may be that respondents found this attribute difficult to understand or maybe a certain proportion of respondents have a positive preference associated with the introduction of new marine species.

As well as being able to examine the changes in utility associated with respondents' preferences, the inclusion of a monetary amount in the form of a tax allows the estimation of respondents willing to pay for or willingness to accept changes to the marine environment. Using formula (8) given above, the welfare impact of a change in the marine environmental attributes from the status quo scenario to 3 possible future scenarios representing a low level of degradation to the marine environment, a medium level of degradation to the marine environment and a high level of degradation to the marine environment are also calculated. These are 3 possible future scenarios that might come to pass should the MSFD not be implemented in full. Results of the scenarios are shown below and are based on the results of the random parameter logit choice model presented in table 6. It is assumed that if the MSFD is implemented in full GES will be achieved. Therefore the alternative degradation scenarios are compared against the attribute levels associated with the achievement of GES as shown in the final column of table 7 (in appendix B). The scenarios consist of a best guess of how the ecosystems will evolve should the MSFD not be implemented in full but this may change based on further information arising from the MFSD assessment that is ongoing in Ireland at present.

The results from Table 7 show that the non-use cost of degradation resulting from not implementing the MFSD in Ireland, as measured in terms of the welfare impact on society, could be large. The estimated compensating surplus per person varies between €99.31 for the low degradation scenario and €217.77 for the high level of degradation scenario. The Irish adult population (aged over 16) stood at 3,439,565 individuals according to the last Census in 2011. Aggregating these estimates up to the relevant population shows that compensating surplus would range between €343 million for the low degradation scenario to €749 million for the high degradation scenario per year. Confidence intervals were generated using the simulation method proposed by Krinsky and Robb (1986).

6. Discussion and Conclusions

This paper presented the results of the first study to attempt to value the 'Cost of Degradation' of the marine environment as set out in the MSFD using the choice experiment approach. As such, it demonstrated the usefulness of the methodology in assessing the welfare impact of changes in a range of marine ecosystem services that align with the 11 marine environmental descriptors outlined in the Directive. The use of the CE approach is also in line with the EU Commissions expectations that Member States carry out "an economic and social analysis of the use of [their] waters and of the cost of degradation of the marine environment" as an integral part of their initial ecosystem based assessments as it enables the researcher to consider the welfare impacts of changes in the marine environment across a range of ecosystems.

It is envisaged that implementation of the MSFD will lead to significant changes within the EU in relation to how the marine environment is managed. The results presented in this paper demonstrate that the Irish people attach a high value to the changes that may occur under future marine policy scenarios. The aggregated values show that the mean values range from €343 million up to €749 million. The use of CE also allows scenarios different to those modelled here to be estimated and these models can be changed if needed, based on the results of the initial scientific assessment being completed at present by the Irish Department of the Environment (and by all member states), as required by the MSFD.

The non-use value associated with the achievement of GES, arising from the MSFD, will need to be assessed in conjunction with how the MFSD will affect the provision of ecosystem goods and services before policymakers can make any marine planning decisions aimed at achieving the Directive's objectives. However, if as it has been suggested by others (Bertram and Rehdanz, 2012, McVittie and Moran, 2010), non-use values compose a significant portion of the total economic value of GES in marine waters then derogations from meeting the requirements of the MFSD may be low.

The EC-DGE (2010) report examines a number of different approaches to valuing the "costs of degradation". The use of CE for valuing non-use values would fit within the Ecosystem Service Approach to valuation put forward by the European Commission in the report. The Ecosystem Services Approach breaks down the changes in the marine environment by the different ecosystem services that are impacted, such as provisioning services (e.g. fish and aquaculture), regulating services (e.g. waste treatment and carbon sequestration) and cultural services (e.g. recreation and aesthetic values). The two alternatives to the Ecosystem Based Approach put forward by the European Commission in the EC-DGE (2010) are the Cost-Based Approach and the Water Accounts Approach. The Cost Based Approach considers only the costs of meeting the GES targets and could be considered a cost effectiveness approach rather than the cost-benefit analysis (CBA), which the MFSD requires. The Water Accounts Approach uses currently reported national economic data from sectors that would be impacted by the changes arising from achieving GES in the marine waters. The benefits of both the Cost-Based and the Water Accounts approaches are that both the costs and national accounts data are more readily available compared to measuring both the benefits and costs under the ecosystem based approach. However, given that the MSFD is framed in the context of the Ecosystem Approach, with Good Environmental Status being interpreted in terms of ecosystem functioning and services provision it seems more appropriate to follow the same approach when attempting to estimate, as was done in this paper, the costs of degradation to the marine environment should the MSFD not be implemented in full.

From a policy perspective, the results of our analysis indicate that marine programs that will have a high impact upon the welfare of the Irish public are those that target pollution and ensure that fisheries are both sustainable and safe to eat. The next highest change in welfare would be from policies aimed at reducing physical impacts to the marine waters including those from marine construction and drilling. Interestingly, the change from sustainable and safe-to-eat seafood to unsustainable but safe-to-eat seafood is associated with a higher change in utility (1.252) than those related to biodiversity and prevention of new invasive species.

There are some limitations that need to be kept in mind in terms of the analysis presented in this paper. For many of the attributes, the worst case levels have significant and large standard deviation parameter values indicating that preferences may vary widely from the means. Further investigation is needed to try and explain why such a wide range of preferences exist and how these preferences are distributed. This could be accompanied by examining the effect of attitudes (collected in this survey) on choice decisions and seeing if they suggest reasons for heterogeneity within preferences. Additionally, the construction of the attributes from the MSFD GES descriptors for use in the CE assumes that there is no correlation between them. While this was controlled for to some extend in the modelling process through the specifications of the Cholesky matrix, which facilitates a degree of correlation in taste attribute variation, the implications for valuing the benefits of programmes of measures that affect more than one descriptor require further consideration.

Finally, it should be noted that the assessment of the impact of human activity on the marine environment should be carried out at the regional seas level. Many of ecosystem loss and degradation problems such as eutrophication of coastal waters have to be viewed at the regional sea/catchment scale. As Turner et al. (2010) point out, the drivers and pressures acting on the marine environment, e.g. agricultural intensification/expansion etc., are located in physical catchments or political designations, which extend well beyond a countries own coastal zone. As such, it may be more appropriate for a CE such as that presented here to be conducted across member states sharing a coastline at a regional sea level[9]. This would be an interesting avenue for future work where cross country differences in cultures and attitudes to the environment would have to be controlled for.

Despite the above limitations, this paper is timely. The requirement for EU Member States to carry out "an economic and social analysis of the use of [their] waters and of the cost of degradation of the marine environment" as an integral part of their initial assessments (Article 8(1c) MSFD) means that methodologies such as that employed

[9] In the first stage of the MSFD assessment process all member states have analysed the drivers, pressures and impacts arising within their own borders and acting on their own adjacent marine waters. It is envisaged by these authors that the necessary regional sea level perspective will become more evident in subsequent follow up assessments that are required under the specifications of the MSFD.

in this paper will be necessary. Indeed, CE has already been shown to be useful for estimating the value of benefits both for changes to the marine environment and other EU Directives related to the environment. EC-DGE (2010) noted that while value transfer was used for undertaking economic studies needed for the WFD the use of value transfer for MSFD benefit analysis may be limited as there is not a sizeable enough literature related to the marine ecosystem service valuation exercises available relative to that which was available to the WFD. However, with this study and more like it, a sufficient number of primary valuations may lead to more use of value transfer within the marine environment using perhaps the meta-analysis methodology employed previously for analysing coastal recreation service benefits by Ghermandi and Nunes (2013).

This study therefore contributes both to the expanding marine valuation literature and to the implementation of the MFSD since it demonstrates how member states might approach the required estimation of ‘the cost of degradation’, using a method that is in line with the concept ecosystem based marine management. It is hoped that further valuation studies akin to this study will be undertaken once the initial MSFD assessment has been completed by all EU member states. This would greatly aid the comparison of the costs and benefits of regional sea level marine policies across EU Member States. Finally, while future uncertainty will always remain in relation to the future state of any ecosystem, the CE approach presented in this paper and the accompanying scenario analysis is a means of dealing with that uncertainty and can provide relevant marine policy makers with useful information on costs associated with a range of possible future states of the marine environment.

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Appendix A

Covariance Matrix

	Bio M.	Bio D.	NN. M.	NN. I.	N.S. Fish	U.H. Fish	Pol. M.	Pol. I	Phy. M.	Phy. L.	A.S.C.
Bio M.	0.195 (0.198)										
Bio D.	-0.537** (0.256)	3.002*** (0.495)									
NN. M.	-0.092 (0.074)	-0.283 (0.229)	0.428** (0.194)								
NN. I.	-0.153 (0.127)	0.231 (0.262)	0.475*** (0.175)	0.883*** (0.264)							
N.S. Fish	0.178 (0.153)	- 0.638*** (0.245)	0.092 (0.109)	0.253 (0.162)	0.707*** (0.237)						
U.H. Fish	-0.085 (0.107)	-0.105 (0.370)	0.704*** (0.240)	1.234*** (0.312)	1.411*** (0.332)	4.811*** (0.829)					
Pol. M.	-0.081 (0.084)	-0.330 (0.246)	0.422** (0.184)	0.320* (0.181)	0.219 (0.173)	1.433*** (0.344)	0.979*** (0.314)				
Pol. I	0.179 (0.131)	- 2.293*** (0.463)	0.992*** (0.337)	0.460 (0.347)	0.444 (0.275)	1.838*** (0.500)	1.754*** (0.417)	5.173*** (0.858)			
Phy. M.	-0.080 (0.090)	0.496** (0.215)	0.133 (0.104)	0.323** (0.157)	-0.271** (0.129)	-0.368 (0.249)	-0.140 (0.150)	0.114 (0.274)	0.704*** (0.196)		

Phy. W.	0.037	0.309	0.178	0.391	-0.245	-0.376	-0.107	0.797**	1.145***	2.226	
	(0.100)	(0.318)	(0.160)	(0.266)	(0.187)	(0.374)	(0.223)	(0.387)	(0.281)	(0.465)	
A.S.C.	-0.149	0.742	0.080	-0.170	-1.750***	-4.057***	-0.229	1.278*	1.300***	1.406**	14.274***
	(0.194)	(0.584)	(0.237)	(0.381)	(0.428)	(0.929)	(0.514)	(0.762)	(0.493)	(0.691)	(2.960)

Significance indicated by * 10%, ** 5% and *** 1% level , Standard Errors in brackets

Correlation Matrix

	Bio M.	Bio D.	NN. M.	NN. I.	N.S. Fish	U.H. Fish	Pol. M.	Pol. I	Phy. M.	Phy. L.	A.S.C.
Bio M.	1.00										
Bio D.	-0.70	1.00									
NN. M.	-0.32	-0.25	1.00								
NN. I.	-0.37	0.14	0.77	1.00							
N.S. Fish	0.48	-0.44	0.17	0.32	1.00						
U.H. Fish	-0.09	-0.03	0.49	0.60	0.77	1.00					
Pol. M.	-0.19	-0.19	0.65	0.34	0.26	0.66	1.00				
Pol. I	0.18	-0.58	0.67	0.22	0.23	0.37	0.78	1.00			

Phy. M.	-0.22	0.34	0.24	0.41	-0.38	-0.20	-0.17	0.06	1.00		
Phy. W.	0.06	0.12	0.18	0.28	-0.20	-0.11	-0.07	0.23	0.91	1.00	
A.S.C.	-0.09	0.11	0.03	-0.05	-0.55	-0.49	-0.06	0.15	0.41	0.25	1.00

Appendix B

Figure 1. Sample Choice Card

Attribute	Choice A	Choice B	Choice C
Biodiversity and Healthy Marine Ecosystem	Biodiversity increases	Biodiversity maintained at current levels	Biodiversity decreases
Non-native species	Irish waters are virtually free of non-native species *(Ecosystem unaltered)*	No new non-native species but existing non-native species remain *(Ecosystem altered by 5%)*	New non-native species invade Irish waters in addition to existing non-native species *(Ecosystem altered by 20%)*
Sustainable fisheries	Healthy fish stock *(stocks sustainable, no contaminant in fish and other seafood)*	Healthy to eat but Non-sustainable fish stock *(stock is over-fished but no contaminants present in fish and other seafood)*	Unhealthy fish stock *(stock over-fished and unsafe levels of contaminants present in fish and other seafood)*
Pollution levels in sea	Pollution decreases	No change in pollution	Pollution increases
Physical Impacts to the Sea	Limited damage	Moderate damage	Wide scale damage
Tax you have to pay	€70	€20	€0

Figure 2. Distributions of biodiversity coefficients

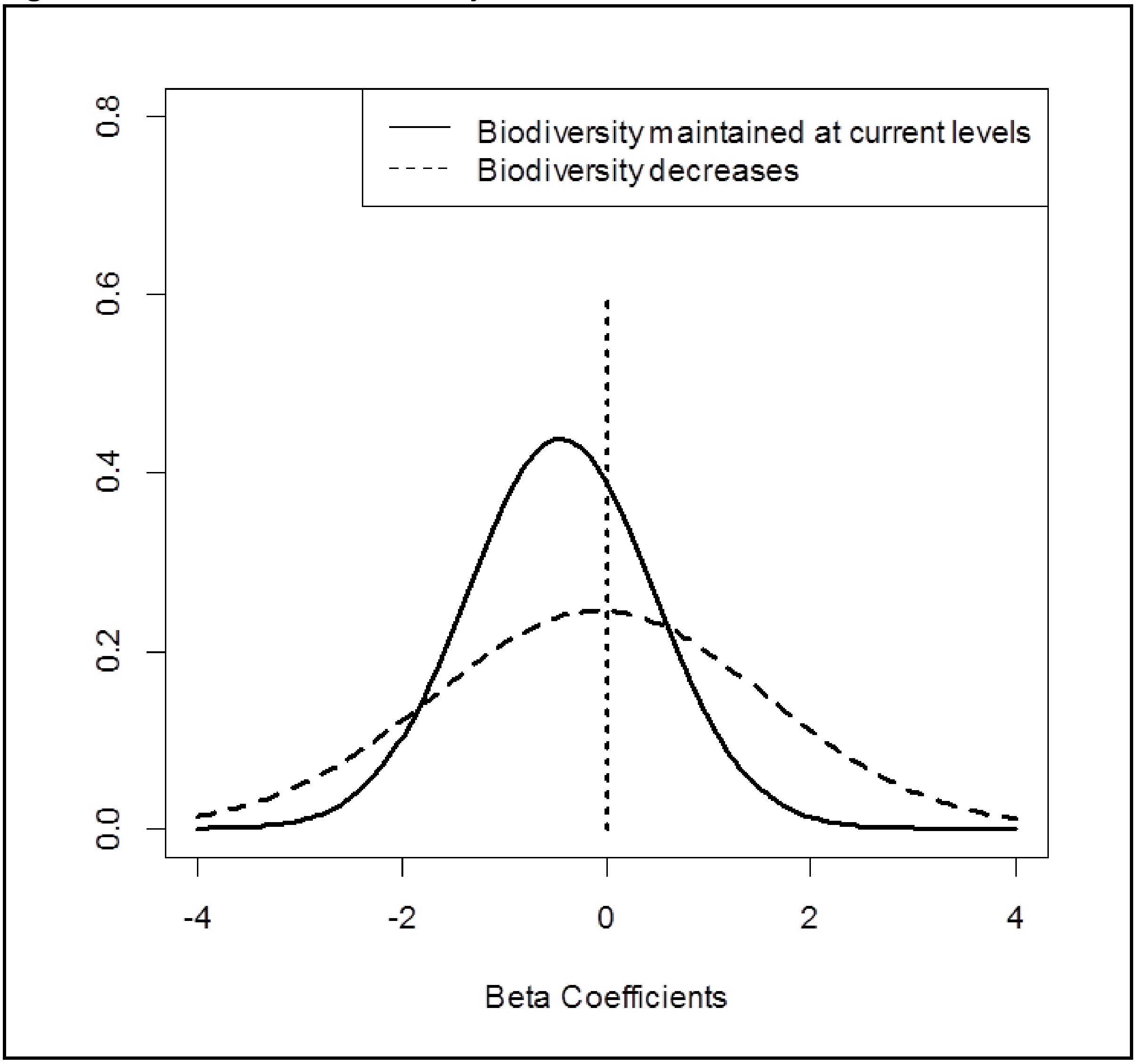

Table 1. Marine Strategy Framework Directive Descriptors of GES

1.	Biological diversity is maintained, including sufficient quality and quantity of habitats and species.
2.	Marine food webs occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of each species.
3.	Healthy stocks of all commercially exploited fish and shellfish which are within safe biological limits.
4.	Contaminants in fish and other seafood for human consumption do not exceed unhealthy levels.
5.	Concentrations of contaminants are at levels not giving rise to pollution effects.
6.	Human-induced eutrophication is minimised.
7.	Marine litter does not cause harm to the coastal and marine environment.
8.	Non-indigenous species introduced by human activities have minimal affect on native ecosystems.
9.	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded.
10.	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
11.	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Table 2. Combination of the MSFD descriptors to create the CE attributes

	MSFD descriptor of GES	CE Attribute
1.	Biological diversity is maintained including sufficient quality and quantity of habitats and species.	*Biodiversity and Healthy Marine Ecosystem*
2.	Marine food webs occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of each species.	
3.	Healthy stocks of all commercially exploited fish and shellfish which are within safe biological limits.	*Sustainable fisheries*
4.	Contaminants in fish and other seafood for human consumption do not exceed unhealthy levels.	
5.	Concentrations of contaminants are at levels not giving rise to pollution effects.	*Pollution levels in sea*
6.	Human-induced eutrophication is minimised.	
7.	Marine litter does not cause harm to the coastal and marine environment.	
8.	Non-indigenous species introduced by human activities have minimal affect on native ecosystems.	*Non-native species*
9.	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded.	*Physical Impacts to the Sea*
10.	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	
11.	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	

Table 3. Levels and brief description of the attributes as per choice cards

Attributes	*Option C Level (status quo)*	*Alternative Levels*					
Biodiversity and Healthy Marine Ecosystem	Biodiversity decreases	Biodiversity maintained at current levels			Biodiversity increases		
Sustainable fisheries	Unhealthy fish stock *(stock over-fished and unsafe levels of contaminants present in fish and other seafood)*	Healthy to eat but Non-sustainable fish stock *(stock is over-fished but no contaminants present in fish and other seafood)*			Healthy fish stock *(stocks sustainable, no contaminant in fish and other seafood)*		
Pollution levels in sea	Pollution increases	No change in pollution			Pollution decreases		
Non-native species	New non-native species invade Irish waters in addition to existing non-native species *(Ecosystem altered by 20%)*	Irish waters are virtually free of non-native species *(Ecosystem unaltered)*			No new non-native species but existing non-native species remain *(Ecosystem altered by 5%)*		
Physical Impacts to the Sea	Wide scale damage	Moderate damage			Limited damage		
Tax	€0	€5	€10	€20	€30	€45	€70

Table 4. Characteristics of this survey versus Census 2011[1]

	This survey (n=812)	Census 2011 – Republic of Ireland
Average Age (Years)	44.6	44.8
Gender (% Male)	49.8	49
Nationality (%Irish)	90	86
Education (% To primary level)	10	16
Education (% To secondary level)	56	53
Education (% To third level)	34	31
Marital Status (% Single)	29	27
Marital Status (% Married)	53	51
Marital Status (% Other)	18	12
Income[2] (€ per year)	33,300	36,138[2]

1. Note that that values refer to population aged 18+.
2. Income is only presented for those working who reported their personal income in the survey (n=185). This subsample is compared to available national data based on average earnings for third quarter, 2012 (CSO, 2012).

Table 5. Reasons for always choosing status quo option C

	All reasons % (n=411)	One reason only % (n=244)
I cannot afford to pay	52.55	47.54
I object to paying taxes	17.76	8.2
The improvements are not important to me	4.62	0.82
The 'No Change' option is satisfactory	3.65	2.46
The Government/ County Council/EU or other body should pay	29.68	13.93
I don't believe the improvements will actually take place	18.98	9.43
Those who pollute the seas and ocean should pay	19.22	7.79
I didn't know which option was best, so I stayed with the 'No Change' option	4.38	3.28
I don't use the sea or marine environment	3.65	1.23
Don't know	1.46	2.46
Other	9.49	2.87

Table 6. RPL model results

Random parameters	**Coefficient (S.E)**	**Standard Deviation (S.E.)**	**Implicit Prices (€)**
Biodiversity maintained at current levels	-0.451*** (0.161)	0.911*** (0.215)	-16.70
Biodiversity decreases	-0.074 (0.130)	1.629*** (0.158)	-2.74
Existing non-native species remain	-0.746*** (0.116)	0.686*** (0.143)	-27.63
New invasive species	-0.683*** (0.124)	1.110*** (0.179)	-25.30
Safe to eat but non-sustainable fisheries	-0.720*** (0.151)	1.195*** (0.172)	-26.67
Unsafe to eat and non-sustainable fisheries	-1.972*** (0.261)	2.614*** (0.219)	-73.04
No change in pollution levels	-0.763*** (0.153)	1.040*** (0.280)	-28.26
Increase in pollution	-2.008*** (0.211)	2.121*** (0.237)	-74.37
Moderate damage	-0.577*** (0.093)	0.969*** (0.158)	-21.37
Wide scale damage	-1.154*** (0.128)	1.645*** (0.268)	-42.74
ASC (Status Quo)	-3.463*** (0.795)	4.721*** (0.619)	
Non-random parameters			
Cost	-0.027*** (0.003)		
Log likelihood function	-2895.44		
AIC	5946.88		
BIC	6454.35		
Number of obs.	4944		

Significance indicated by * 10%, ** 5% and *** 1% level

Table 7. Attribute levels and compensating surplus value estimates for 3 alternative levels of degradation (€ per person per year)

Attribute	Scenario 1: Low level of degradation	Scenario 2: Medium level of degradation	Scenario 3: High level of degradation	Marine waters at GES
Biodiversity and Healthy Marine Ecosystem	Biodiversity maintained at current levels	Biodiversity decreases	Biodiversity decreases	Biodiversity increases
Sustainable fisheries	Healthy to eat but Non-sustainable fish stock *(stock is over-fished but no contaminants present in fish and other seafood)*	Healthy to eat but Non-sustainable fish stock *(stock is over-fished but no contaminants present in fish and other seafood)*	Unhealthy fish stock *(stock over-fished and unsafe levels of contaminants present in fish and other seafood)*	Healthy fish stock *(stocks sustainable, no contaminant in fish and other seafood)*
Pollution levels in sea	No change in pollution	Pollution increases	Pollution increases	Pollution decreases
Non-native species	No new non-native species but existing non-native species remain *(Ecosystem altered by 5%)*	No new non-native species but existing non-native species remain *(Ecosystem altered by 5%)*	New non-native species invade Irish waters in addition to existing non-native species *(Ecosystem altered by 20%)*	Irish waters are virtually free of non-native species*(Ecosystem unaltered)*
Physical Impacts to the Sea	Limited damage	Limited damage	Wide scale damage	Limited damage
Compensating Surplus (€/ person/year)*	-99.31 (-140, -64)	-131.23(-166, -102)	-217.77 (-275, -172))	-
Total Population Compensating Surplus (€m/year)*	-342 (-481,-220)	-451 (-571, -351)	-749 (-946, -592)	-

*95% confidence interval in brackets)

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